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Species transfer from multiple rising bubbles in periodic domain

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The present study investigates species transfer from buoyancy driven *multiple* rising bubbles in quiescent liquid. The periodic computational domain corresponds to a regularly repeating cuboid domain in an infinitely large physical domain, relevant to several industrial applications like chemical reactors, carbonation, fermentation, waste water treatment etc. Utilizing transport-physical property corresponding to the dissolution of oxygen from rising bubbles in water, results in different non-dimensional parameters as, Galileo number, $Ga = 7$, Bond number, $Bo = 0.079$, and Schmidt number, $Sc = 10$; with an increased dynamic viscosity of water for affordable computational expenses. The interface separating dispersed phase and carrier phase is captured with a *novel mass-conserving* Conservative Diffuse Interface (CDI)[1] on a three-dimensional uniform Cartesian coordinate with MPI-based domain decomposition. Further for modeling species transfer across the interface with Henry's coefficient for discontinuous concentration field, the interfacial mass transfer term similar to Mirjalili et al.[2] is utilized and validated as shown in Figure 1(a). Initiating 12 bubbles from random positions in the computational domain with minimum 2D center-to-center distance between the bubbles as shown in Figure 1(b), the bubble interactions are avoided as shown in Figure 1(c). Varying different parameters like void fraction (VF), bubble radius, Bo, Ga, and Sc, their effects on species dissolution from multiple rising bubbles are investigated and the results for two different void fractions are shown as in the Figure 1(d). This study is significant as it demonstrates the influence on species dissolution for physically relevant applications involving multiple bubble, a common phenomenon unlike the widely utilized single bubble studies.

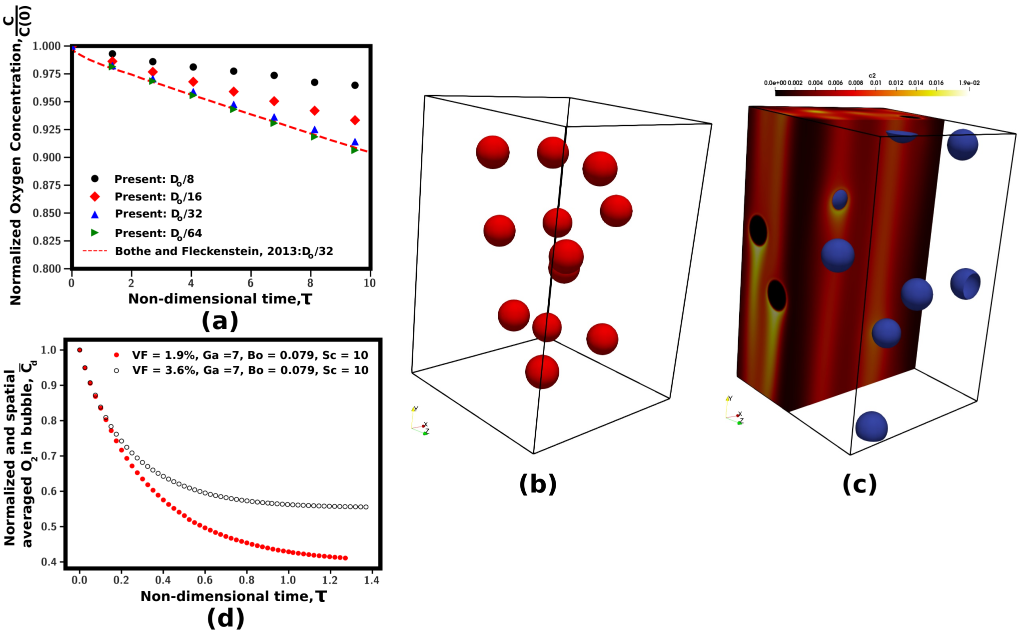

Figure 1: Utilizing the current Conservative Diffuse Interface (CDI) approach, once (a) validated with previous published result, the multiple rising bubble is simulated with (b) initial random arrangement of the bubbles. As shown at (c) non-dimensional time $\tau = 0.3$ with species dissolution in carrier phase, further cases are simulated whereas only the (d) effect of void fraction is shown.

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[1]Salimi et al., *Journal of Computational Physics* **523**, 113683 (2025)
[2]Mirjalili et al., *International Journal of Heat and Mass Transfer* **197**, 123326 (2022)